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ORIGINAL ARTICLE

Geotechnologies applied in epidemiological studies on cases of covid-19: a narrative review

Geotecnologias aplicadas em estudos epidemiológicos sobre os casos de covid-19: revisão narrativa

Geotecnologías aplicadas en estudios epidemiológicos sobre casos de covid-19: revisión narrativa

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ABSTRACT

Background and objectives: the applied geotechnologies are essential in helping the development of epidemiological studies that aim to identify and distribute health events in specific populations and territories, in addition to verifying the factors that influence the occurrence of these events, intending to apply the evidence in strategies of disease planning and control as in the covid-19 pandemic. This study aimed to present the scientific evidence that has been produced on geotechnologies applied in epidemiological studies on cases of covid-19. **Methods**: this is a descriptive narrative literature review (NLR). To guide the study, the following research question was elaborated: what has been studied about applied geotechnologies in epidemiological research on covid-19 cases? The search was carried out in October 2021, using the descriptors Geographic Information Systems AND Covid-19 OR SARS-CoV-2 AND Epidemiology AND Spatial Analysis, in Virtual Health Library, Scopus, Web of Science, Portal CAPES. Complementarily, a search was carried out for epidemiological bulletins and booklets on the Brazilian Ministry of Health website. **Results**: nineteen sources of information were selected that fit the objectives for the discussion construction, with three categories of analysis being listed: *Geotechnology application*; *Information management*; *Challenges of epidemiological studies that use secondary data*. **Conclusion:** geotechnology use in epidemiological studies on covid-19 in identifying areas at risk for the infection spread was such remarkable.

Keywords*: Covid-19. Epidemiology. Spatial Analysis.*

RESUMO

Justificativa e objetivos: as geotecnologias aplicadas são essenciais para auxiliar o desenvolvimento de estu-

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dos epidemiológicos que visam identificar e distribuir eventos de saúde em populações e territórios específicos, além de verificar os fatores que influenciam a ocorrência desses eventos, pretendendo aplicar as evidências em estratégias de planejamento e controle de doenças como na pandemia de covid-19. Este estudo teve como objetivo apresentar as evidências científicas que vêm sendo produzidas sobre geotecnologias aplicadas em estudos epidemiológicos de casos de covid-19. **Métodos:** trata-se de uma revisão de literatura narrativa descritiva (NLR). Para nortear o estudo, elaborou-se a seguinte questão de pesquisa: o que tem sido estudado sobre as geotecnologias aplicadas na pesquisa epidemiológica dos casos de covid-19? A busca foi realizada no mês de outubro de 2021, utilizando os descritores Geographic Information Systems AND Covid-19 OR SARS-CoV-2 AND Epidemiology AND Spatial Analysis, na Biblioteca Virtual em Saúde, Scopus, Web of Science, Portal CAPES. Complementarmente, foi realizada busca de boletins e cartilhas epidemiológicas no site do Ministério da Saúde do Brasil. **Resultados:** foram selecionadas dezenove fontes de informação que se enquadram nos objetivos para a construção da discussão, sendo elencadas três categorias de análise: Aplicação da geotecnologia; Gestão da informação; Desafios dos estudos epidemiológicos que utilizam dados secundários. **Conclusão:** o uso da geotecnologia em estudos epidemiológicos da covid-19 na identificação de áreas de risco para a propagação da infecção foi notável.

Palavras-chave: *Covid-19. Epidemiologia. Análise espacial.*

RESUMEN

Justificación y objetivos: las geotecnologías aplicadas son esenciales para ayudar al desarrollo de estudios epidemiológicos que tengan como objetivo identificar y distribuir eventos de salud en poblaciones y territorios específicos, además de verificar los factores que influyen en la ocurrencia de estos eventos, con la intención de aplicar la evidencia en estrategias de planificación y control de enfermedades como en la pandemia de covid-19. Este estudio tuvo como objetivo presentar la evidencia científica que se ha producido sobre geotecnologías aplicadas en estudios epidemiológicos sobre casos de covid-19. **Métodos:** se trata de una revisión descriptiva narrativa de la literatura (NLR). Para orientar el estudio se elaboró la siguiente pregunta de investigación: ¿Qué se ha estudiado sobre geotecnologías aplicadas en la investigación epidemiológica de casos de covid-19? La búsqueda se realizó en octubre de 2021, utilizando los descriptores Sistemas de Información Geográfica Y Covid-19 O SARS-CoV-2 Y Epidemiología Y Análisis Espacial, en Biblioteca Virtual en Salud, Scopus, Web of Science, Portal CAPES. Complementariamente, se realizó una búsqueda de boletines y folletos epidemiológicos en el sitio web del Ministerio de Salud de Brasil. **Resultados:** fueron seleccionadas diecinueve fuentes de información que se ajustan a los objetivos para la construcción de la discusión, siendo enumeradas tres categorías de análisis: aplicación de la geotecnología; Gestión de la información; Retos de los estudios epidemiológicos que utilizan datos secundarios. **Conclusión:** el uso de geotecnología en estudios epidemiológicos sobre covid-19 para identificar áreas en riesgo de propagación de la infección fue tan notable.

Palabras clave: *Covid-19. Epidemiología. Análisis espacial.*

INTRODUCTION

Technological and scientific advances today have been marked by the continuous progress of methods that seek to build knowledge based on the investigation of spatial phenomena. Thus, the technological tools contribute to the survey, analysis and interpretation of spatial information, aiming to assist in the process of planning and management in health with the characterization of territories.[1]

Geoprocessing emerges as a valid instrument for carrying out research in the health area, as it selects data characteristics about diseases and/or injuries in order to distribute them in a geographic space. It is a process that results in the graphic representation of environmental and social relationships that can be determinants of the health-disease process.[2]

Furthermore, it is a method that quantitatively represents the distribution of injuries in incident areas and is available in a geographic information system (GIS), making it possible to collect, process and analyze data as it is a technological resource that operates in front of a graphic database, helping in event distribution with a set of software, methodologies and research data.[3,4]

Given this, geotechnologies contribute to the development of epidemiological studies that aim to identify and distribute health events in specific populations and territories, in addition to verifying the factors that influence the occurrence of these events, with a view to applying the evidence in disease planning and control strategies.[5]

Like the covid-19 pandemic, which emerged at an accelerated pace, new public health problems require investigation to identify how these events are distributed in space and what factors are associated with their evolution.[6] Globally, as of May 18, 2022, there have been 520,372,492 confirmed cases of covid-19, including 6,270,232 deaths.[7]

Covid-19 can present itself as influenza-like syndrome (ILS) or as Severe Acute Respiratory Syndrome (SARS) which presents more severe respiratory symptoms.[8] Therefore, the emergency caused by the pandemic requires commitment from health systems around the world to meet patients' needs quickly and effectively.[9] It is also added that the production of knowledge about the disease

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with the use of geotechnologies helps in understanding the space-time dynamics and can contribute to planning and decision-making to mitigate the disease.

Thus, more recurrent studies comprise space-time analyzes and mapping of diseases, health and social geography, environmental variables, data mining and web-mapping.[10]

Globally, GIS are used as real-time data sources, allowing the monitoring of the epidemiology of morbidity and mortality by covid-19 in affected territories.[10] Thus, the objective was to present the scientific evidence that has been produced on geotechnologies applied in epidemiological studies on cases of covid-19.

METHOD

This is a descriptive narrative literature review (NLR), having as its theme the application of geotechnologies in epidemiological studies on covid-19. Through the production of discussion on the material raised in the form of a theoretical essay, the investigation of the theme allows the theoretical foundation to promote scientific work.[11]

The following steps were taken to prepare the NLR: research question elaboration; search strategy definition; choice of databases; inclusion and exclusion criteria use; time frame definition; data extraction; data analysis; and presentation of NLR.[11]

To guide the study, the research question was elaborated: what has been produced about geotechnologies applied in epidemiological studies on cases of covid-19? The theme, topic and refiner were observed from the research question to guide the choice of descriptors. Thus, "geotechnologies" refers to the theme, "Covid-19", to the theme and "epidemiological studies", to the refiner refers to context.

A search was performed for the descriptors present in Descriptors in Sciences and Health (DeCS) and Medical Subject Headings (MeSH), using only MeSH descriptors in English and Boolean operators AND and OR. Thus, the search was performed using the combination (Geographic Information Systems AND Covid-19 OR SARS-CoV-2 AND Epidemiology AND Spatial Analysis).

Data collection took place in October 2021 in the Medical Literature Analysis and Retrieval System Online (MEDLINE) and Latin American and Caribbean Literature in Health Sciences (LILACS) databases, via the Virtual Health Library (VHL), in addition to Scopus and Web of Science and in Collection of the Coordination for the Improvement of Higher Education Personnel (CAPES - *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*) of dissertations, books/book chapters and government documents. Complementarily, a search was carried out for epidemiological bulletins and booklets on the Brazilian Ministry of Health website.

After conducting research in the data sources, files were exported in the RIS extension, which contain information saved in text format. Then, the extensions were imported into Rayyan, a free web application that assists in the selection of studies for reviews and meta-analyses.

Articles published until October 2021 in Portuguese, English or Spanish, which addressed the application of geotechnologies in epidemiological studies on cases of covid-19 in different contexts around the world were included. Studies that addressed questions about mobility, grief, mortality, development of geospatial surveillance systems and studies that did not have covid-19 morbidity data as a sample were excluded.

According to defined eligibility criteria, the steps below were followed: reading title and abstract in Rayyan; selection of studies that addressed the research question; full analysis of texts that answered the research question; data extraction through a collection script; and interpretive reading and writing the narrative review.

A data collection instrument was designed to answer the research question using an Excel® spreadsheet, available with Microsoft 365®, with the following topics: identification of authors and year of publication; goals); research scenario; data source; analyze; model and/or technique used; tool/software used; and limitations.

As the productions refer to the authorship of a researcher, the review followed the precepts of Law 9.610/98, where the information of analyzed productions was described and cited faithfully as presented by the authors.

RESULTS AND DISCUSSION

For study selection, title and abstract were read in Rayyan, and those that answered the research question were selected. Subsequently, selected texts were read, excluding studies that addressed questions about mobility, mourning, mortality and the development of geospatial surveillance systems. The articles that remained in the final sample underwent data extraction, through a collection script. The article selection scheme is shown in figure 1.

Of the nineteen materials analyzed, it was found that (18) 95.0% refer to articles and (1) 5.0% refer to an epidemiological bulletin. Among the studies, only one was carried out in the national territory and published in Portuguese, while eighteen were published in English. There was an insignificant volume of publications such as booklets, checklists, technical recommendations on geotechnologies and their application in epidemiological studies, highlighting the importance of developing other materials to guide and aid in the development of this type of research. The main publications were from the United States, with (5) 27.0%, China, with (4) 22.0%, Iran and African continent, with (2) 11.0% of the total materials included.

Most studies sourced secondary data from national disease surveillance systems, repositories, and public data from daily reports from government institutes, and had as their main application the use of mapping techniques with application, mainly, of spatial autocorrelation analysis and heat map analysis.

Chart 1 shows authors, objective(s), research setting, data source analysis, model and/or technique used, tools/software used and limitations.

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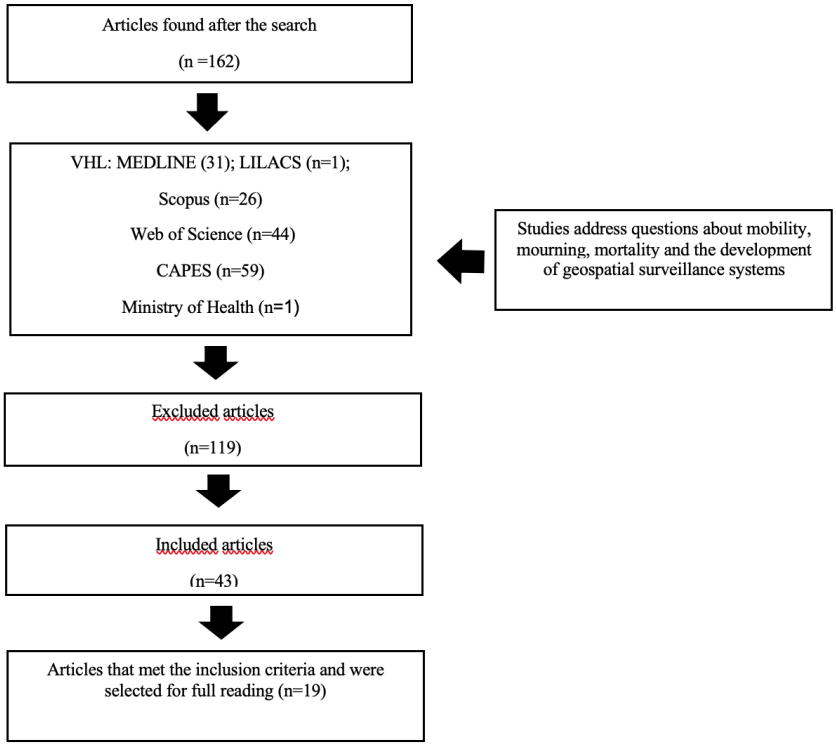

Figure 1. CScheme of selection of materials included in the narrative review.

After reading the documents, we sought to understand how epidemiological studies on cases of covid-19 have been carried out using geotechnologies. Thus, content discussion was divided into the following categories of analysis: *Geotechnology application*; *Information management*; *Challenges of epidemiological studies that use secondary data*.

Geotechnology application

Geotechnologies are used in the mapping of risk areas, seeking answers to the problem in different scenarios around the world, with emphasis on the United States and China, to identify disease distribution in space, as well as the associated factors.[10] Studies show social characteristics such as low literacy and impoverished areas as factors that contribute to a higher occurrence of covid-19, as they are factors associated with areas with a fragile health system and vulnerable to outbreaks.[12]

Among the geographic factors that contribute to the higher occurrence were areas with large population clusters, which are tourist centers and attract visitors from different areas, providing a greater probability of infection.[13] As for economic factors, a study pointed out that socioeconomic groups in unfavorable economic situations are at greater risk of spreading the covid-19 pandemic.[14] Thus, the identification of social, geographic and economic factors can contribute with information that will help health service management.

Several strategies for mapping data were used in approaching cases of covid-19 in the world, including Bayesian statistics. This method can be used as statistical inference of spatial data, estimating parameters of the affected population, testing hypotheses and establishing the correlation present in data.[15] This method was used in studies carried out in Hungary[16] and Germany[17] and sought, respectively, to identify the association of cases of covid-19 with socioeconomic factors and with the district level, and districts with a high risk for spreading the disease and social deprivation as a risk factor for a worse prognosis were identified.

The Moran Index was another technology frequently used in conducting epidemiological studies. It was used as a measure to identify spatial autocorrelation and to ascertain the existence or not of conditions and the spatial pattern using morbidity and mortality indicators, which can be associated with socioeconomic and sociodemographic indicators, sanitary conditions and spatial segregation.[18]

The Global Moran Index aims to identify patterns of spatial distribution of indicators. In studies on covid-19, the use of this technology aims to determine the factors influencing the incidence.[19-21] Meanwhile, the Local Indicator of Spatial Association (LISA) is used to identify clusters locally and their statistical significance.

A study carried out in Gansu Province, China, used mixed techniques and identified the type and degree of spatial agglomeration using the Global Moran Index and statistically significant hot spots through kernel density estimation.[22]

In the United States, studies have used geostatistical techniques to identify the spatial autocorrelation

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Chart 1. Distribution of materials included in the review. Imperatriz, Maranhão, Brazil 2022.

Authors	Objective(s)	Setting	Data source	Analysis, model and/or technique used	Tools/softwares used	Limitations
OROSZI et al., 2021	Describe the morbidity, mortality, lethality, and increased mortality of covid-19 in a nationwide study of Hungarian municipalities, exploring the association with socioeconomic status.	Hungary	Hungary's Notifiable Disease Surveillance System, operated by the National Center for Public Health (NPHC).	Spatial distribution with smoothed Bayesian technique.	Scan Statistic - SaTScan; The Rapid Inquiry Facility (RIF).	Underreporting of cases and lack of access to data on tests that weaken the inference that areas with lower incidence (poor areas) have a deficiency in the health system with lower tests.
HASSAAN, et al., 2021	Identify the best GIS-based model that can explore, quantify, and model determinants of covid-19 incidence and fatality.	African continent	World Health Organization Portal, World Bank Group and Global Health Observatory.	Spatial autocorrelation analysis (Moran Index), Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR).	ArcGIS.	Missing or incomplete data. Accuracy of incidence reports was the main hurdle.
OZDENEROL, E.; SEBOLY, J. et al, 2021	Associate lifestyle characteristics with covid-19 infection and US county-level death rates and sequentially map the impact of covid-19 on different lifestyle segments.	United States	Location data from Esri, morbidity data from USAFacts.	Mapping technique, spatial autocorrelation analysis.	GIS.	This is a population study, subject to underreporting bias, in addition to the lifestyles of a county not representing all families in that county. The results inferred for a group cannot be taken into account for the individual level.
HENNING et al., 2021	Identify the social, geographic and economic factors that have contributed to a higher prevalence of covid-19.	Pennsylvania, United States	Data from positive tests for covid-19, electronic medical record and Google map bank.	Mapping techniques, spatial distribution of prevalence, spatial dependence.	ArcGIS Desktop 10.7.	Underreporting of cases, and results may be underestimated if a significant number of people tested positive are in different postal codes than those observed in the study.
GANGWAR, H. S; RAY, P. K. C., et al 2021	Identify the social, geographic and economic factors that have contributed to a higher prevalence of covid-19.	India	COVIDindia website and Office of the Registrar General, Census Commissioner of India and WHO Coronavirus Disease Panel.	Mapping techniques, spatial and temporal distribution.	GIS.	Underreporting, data inconsistency and ecological fallacy.
QI et al., 2021	Analyze data from laboratory-confirmed cases in Shandong Province and describe the epidemiological characteristics and transmission chains of covid-19 to explain the details of transmission between close contacts.	Shandong, China	Laboratory records, Shandong statistical yearbook and census in Shandong Province.	Spatial distribution, Spatial and spatiotemporal sweep using the Poison model.	Software R 3.6.0, SaTScan v9.6 and ArcGIS 10.5	Underreporting and ecological fallacy.
POURGHASEMI, et al 2020	Analyze coronavirus outbreak risk factors to identify high-risk areas of infection and assess infection behavior in Fars Province, Iran	Fars Province, Iran	Ministry of Health and Medical Education of Iran.	Time series analysis, autoregressive model	Machine learning algorithm based on geographic information system (GIS).	Underreporting and inferences for groups cannot be considered for the individual level.
MOHAMMADEBRAHIMI, et al., 2021	Investigate the epidemiological characteristics of cases of covid-19 in northeastern Iran by mapping the spatiotemporal trend of the disease.	Iran	Mashhad University of Medical Sciences (MUMS).	Kernel density estimation and spatial autocorrelation (Moran Index).	R software version 4.0.5 (R Foundation for Statistical Computing) and Microsoft Excel 2016.	Lack of data on patients who were still hospitalized at the time of reporting. Spatial and spatiotemporal dynamics need to be studied over a longer period in order to provide more effective solutions.
LIU et al., 2021	Analyze the space-time spread of covid-19 in Wuhan and its influencing factors.	Wuhan, China	National infectious disease surveillance system, population data from statistical yearbooks published by Wuhan in 2018, and number of public spaces from Google Maps.	Trend in the distribution of the number of cases, Moran Index.	R software (version 3.6.2), ArcGIS 10.2 and GeoDa 1.14.0.0.	The retrospective observational study design precludes causal inference. Second, due to the date, they were taken from the national infectious disease surveillance system. Other factors such as incubation period, medical treatment strategies and vital status were not available.
LADOY, et al 2021	Characterize the spatial and temporal dynamics of the first wave of SARS-CoV-2 infections in the state of Vaud (western Switzerland) through the detection and location of clusters.	Vaud, Switzerland	Results of SARS-CoV-2 RT-PCR tests carried out by the Laboratory of Microbiology at the Lausanne University Hospital (CHUV).	MST-DBSCAN (Density-Based Spatial Clustering of Applications with Noise).	SaTScan software (version 9.6.1).	Results refer to clusters and inferences may not be maintained at the individual level.

WU, J.; SHA, S. et al 2021	Identify patterns of cases of covid-19 in the USA.	United States	Johns Hopkins University publicly accessible on the GitHub website.	Moran Index, trend component, seasonal and residual component, K-means cluster analysis.	Spatial Autocorrelation (Global Moran's I) in ArcGIS 10.1, Python 3.7 "scikit learn" package.	Covid-19 data were at the county level only and could not explore clusters in smaller spatial units. K-means clustering has its own weakness, linear separability of data and K-value selection likely influence clustering results. There was no investigation of risk factors or covariates for covid-19.
OLUYOMI et al., 2021	Assess associations between 29 neighborhood-level characteristics and the incidence of COVid-19 in Harris County, Texas.	Harris County, Texas (USA)	American Community Survey (ACS), data from 2014-2018.	Negative binomial regression (NBR) technique, geographically weighted Poisson regression (GWPR).	Geostatistics Wizard in ArcGIS Pro 2.6, Stata 16.0.	Use of secondary data made available by public health authorities, not being able to guarantee whether they are accurate and timely. Inadequate access to tests and delayed test results can compromise the sample, and independent variables used in the study may not cover all factors that influence covid-19 transmission.
FASONA et al., 2021	Identify areas of vulnerability for the occurrence of cases of covid-19.	Nigeria, West Africa	Nigeria Center for Disease Control (NCDC).	Spatial distribution and autocorrelation, multiple regression analysis.	Database was loaded from ArcGIS into IBM SPSS Statistics 20 software.	Incompleteness of accessed data, underreporting.
BUSEMA et al., 2020	Identify the distribution of initial cases of covid-19 using Topological Weighted Centroid (TWC).	Italy	Official repository of Italian civil protection.	Mapping techniques, analysis of heat maps.	TWC evolutionary algorithm.	Little data such as latitude and longitude of cities where at least one case of covid-19 was detected.
LIAO et al., 2020	Analyze the covid-19 epidemic in an impoverished area, assess the control effect and explore future control strategies.	Liangshan, China	Data collected from Liangshan Province's Notifiable Infectious Diseases Reporting Information System (NIDRIS) and Earth System Science Data Sharing Infrastructure.	Mapping techniques, spatial and temporal analysis.	Excel 2010 software, and SPSS 17.0 and ArcGIS10.2.	Few cases, not being possible to calculate the incidence or analyze the trend of the epidemic, difficulty in sharing information between regions, we cannot trace the source of infection of the eight imported cases.
RAMÍREZ, I.; LEE, J. 2020	Investigate covid-19 emergency spatial patterns in Colorado counties.	Colorado, United States	Public data from daily reports and geospatial information from CDPHE* and its open data portal.	Mapping techniques, incidence distribution, heat map analysis.	ArcGIS Pro, IBM-SPSS, inverse distance weighing (IDW) algorithm.	Short time frame and rapidly evolving context of the pandemic, which has included changes in new case counts and deaths as new information updates previous daily summaries posted online.
FAN et al., 2020	Determine the epidemiology of coronavirus disease (covid-19) in a remote region of China.	Gansu Province, China	Gansu Provincial Center for Disease Control and Prevention official website.	Local Indicators of Spatial Association (LISA) (local Moran Index), Fisher's exact test, non--parametric Brown-Mood tests.	ArcGIS 10.2.2 software.	Difficulty in calculating county-level incidence or esti-mating risk factors affecting SARS-CoV-2 transmission in Gansu province due to relatively small number of cases and short study period.
ROHLEDER, S.; BOZORGMEHR, K. et al 2021	Analyze the spatiotemporal epidemiology of SARS-CoV-2 incidence and associated deaths at district level since the beginning of the pandemic in Germany.	Germany	Robert-Koch Institute, social reporting system in statistics, and federal agency for cartography and geodesy.	Bayesian space-time model.	R software (V. 3.6.3), R-INLA package and tmap package.	Notification data limitations cannot be resolved with the proposed analyses. Local variations and adaptations of the national testing guideline may affect incidence variations.
BRASIL, 2021	Present the analysis referring to the epidemiological week 38 of 2021.	Brazil	Diaries reported by the State Health Department (SHD) to the Ministry of Health.	Mapping technique, space-time analysis.	GIS.	Underreporting of cases and subject to errors in the extraction, treatment and cleaning processes in the database.

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between economic, social and environmental variables with disease occurrence and to identify factors that provide the increase in the number of cases of covid-19.[23,24] In a community in Pennsylvania, a spatial autocorrelation was observed between the occurrence of cases and the number of superstores (large sales area, greater than that of a traditional supermarket with approximately 25 to 36 checkouts) per ZIP code during the first four weeks and between first six weeks of propagation.[23]

The spatial scanning technique is commonly applied to identify probable clusters related to diseases that affect the population. As a result, it identifies how a given disease is distributed in the territory – uniformly or heterogeneously – detecting protection or risk clusters with statistical significance for a given disease and/or injury.[25]

The spatial scanning technique application revealed the covid-19 evolution dynamics in a study carried out in China, highlighting questions about transmission between close contacts.[13] The study aimed to help disease surveillance systems in terms of directing intervention to the places that require more attention, contributing to the agility of the process of combating the pandemic. [25]

Poisson regression models are commonly used to model data counts in response to a dependent variable. These models help in determining the predictive effect of occurrence of events in space or in dependent variables in response to an independent variable. In Costa Rica, applying the model using data on covid-19 allowed the visualization of the behavior of active cases through graphs.[26]

In Nigeria, a study with multiple regression analysis application showed the spatial vulnerability scenario for the spread of covid-19 infection using 12 spatial conductors referring to the proximity of airports, road traffic and flow of people from outside the country, identifying that between 96.6 and 99.0% of the total variation in covid-19 infections can be explained by the applied predictors.[27]

Mapping covid-19 through kernel density estimation consists of quantifying the relationships of points within a radius (R) of influence and analyzing the patterns of a dataset. The kernel technique soothes the surface by calculating the density for each area under investigation.[28] Its technical application was evidenced in a study carried out in Iran,[29] with space-time patterns of confirmed cases of covid-19, over eight periods of time, and suburban risk areas were observed, places where the disease spread rapidly to the inner city.

In the state of Colorado (United States), the identification of hot areas for disease occurrence identified that the social determinants related to severe cases of covid-19 were population density, poverty and unemployment, suggestive of rural areas.[24]

In addition to the techniques mentioned so far, others were used, such as the autoregressive model in the analysis of time series that seeks to predict the occurrence of future cases and identify risk areas for infection evolution, used in a study carried out in Fars Province, Iran.[30]

Geotechnology application was also observed in epidemiological bulletins issued by the Brazilian Ministry of Health, with records of the reduction dynamics, stabilization and increase in record of new cases of covid-19 and representation of spatial distribution of incidence rates among the federative units. Its application brings important information in a didactic way, facilitating the visualization and understanding of how covid-19 has been distributed.[31]

However, it is evident, in this investigation, the scarcity of other materials that are not scientific articles and that would help in a broad elucidation of the knowledge that is being produced on the subject, such as booklets and manuals.

Information management

This rationale refers to the various strategies on information management, a fundamental aspect in storing, processing and analyzing data for the development of health products and services.[32]

Studies that work with case series intend to understand the disease behavior by distributing the events by categorical variables with clinical, epidemiological and sociodemographic aspects and also carry out analyzes in terms of time and space. The broader dimension of these studies refers to the representation of a set of cases that are reported in the information systems for diseases or conditions that require compulsory notification.[5]

Thus, the strategies for carrying out these studies require a series of procedures to enable the collection of data to characterize an event. There are different strategies for acquiring information, such as the use of existing data, which are already registered, or the use of data collected through laboratory tests or interviews that have not yet been registered, in addition to non-existent data that are generated through the application of a intervention.[5]

With the application of geotechnologies in the analysis of cases of covid-19, it was possible to observe that most studies have secondary data as a source mainly from national disease surveillance systems, repositories, public data from daily reports from governmental institutes,[16,17,20,22,24,27,30-33] electronic medical records,[23] laboratory data[13,29,34] and data collection from the WHO portal.[14,19]

In addition to this, studies use the WHO Global Health Observatory to identify factors associated with the disease, since the portal provides analyzes and reports on global health with statistical data by country and maps of the patterns of investigated diseases.[19,35]

For the association of health determinants with the occurrence of covid-19, studies use data from free access portals to collect data on population density, poverty, unemployment and area of concentration of cases, in addition to systems and programs with social, demographic and cartographic reports used in determining the incidence and association of cases at the neighborhood and district level.[17,24]

Challenges of epidemiological studies that use secondary data

The epidemiological analysis of diseases, especially emerging diseases, deserves attention regarding the issue of underreporting of cases, which is closely related to the incipient performance of tests. A study carried out in the state of Santa Catarina, which took into account

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the first 16 epidemiological weeks and was based on the number of hospitalizations due to SARS in 2020, estimated that the underreporting of records of cases of covid-19 was close to 82%.[36]

Underreporting is a bias usually described in epidemiological studies, also applicable to those that approach cases of covid-19.[13,14,16,23,30,31,37,38] This bias creates subspaces of epidemiological silences, and occurs mainly due to the lack of physical and human resources in health facilities, with insufficient testing and incompleteness in reported data. [13,14,16,23,30,31,37,38]

Underreporting may be associated with the reduced number of professionals specialized in caring for critically ill patients, as well as health care network dynamics, with limited or non-existent epidemiological surveillance systems, a factor reported in a study carried out on underreporting and regional inequalities in Brazil.[40]

Inadequate access to tests and their results was identified as limiting factor in carrying out studies on covid-19, as it compromises the analyzes used[38] as well as adaptations of national guidelines on testing that may affect variations in incidence.[17] Moreover, the absence of data weakens the inference that areas with lower incidence have fragile health systems with lower testing rates.[16]

Another bias was ecological fallacy, making it necessary to consider the validity of the aforementioned associations. In theory, there is an ecological correlation, since the indicators are grouped; however, the relationship identified at an aggregate level does not necessarily hold at the individual level.[41]

CONCLUSION

With this review, using geotechnologies in epidemiological studies on covid-19 was evidenced in the identification of risk areas for infection spread as well as factors associated with its evolution. Such evidence is fundamental to guide the strategies of managers in combating and controlling the disease, aiming not only at the occurrence of cases, but also at identifying and taking care of the social, demographic and economic factors that are determinants of the health-disease process. Furthermore, the analyzed studies incorporated statistical tools that valued the findings on distribution, behavior of active cases and formation of clusters.

As a limitation of this review, there is a shortage of other types of material for analysis, since most were scientific articles. This raises the need for greater attention focused on the preparation of booklets, flowcharts, recommendations and checklists that address geotechnologies applied to epidemiological studies, which would help build knowledge on the subject.

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AUTHORS' CONTRIBUTIONS

Janiel Conceição da Silva, Ana Cristina Pereira de Jesus Costa, Adriana Gomes Nogueira Ferreira and Marcelino Santos Neto contributed to study conception, design, analysis and writing; **Janaína Miranda Bezerra, Lívia Maia Pascoal and Floriacy Stabnow Santos** contributed to the planning and design of the article, review and final approval.

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